METHOD OF MANUFACTURING A COMPONENT FOR DROPLET DEPOSITION APPARATUS

The present invention relates to a component for a droplet deposition apparatus and more particularly a nozzle plate for a droplet deposition apparatus. A n ink jet printer is a particularly important example of droplet deposition apparatus.

A nozzle plate is typically attached to a body of a droplet deposition apparatus having a plurality of ink ejection chambers to provide each chamber with a respective droplet ejection nozzle. Due to the accuracy with which ejection nozzles must be formed in the nozzle plate, for example to ensure uniformity of the size and velocity of droplets ejected from the ejection chambers, laser ablation is commonly used to form the nozzles in the nozzle plate. Plastics material such as polyimide, polysulphone or other such laser-ablatable plastics material is commonly used to form the nozzle plate, and after the application of an ink-repellant layer to one face of the nozzle plate, each nozzle is formed by exposing the plate to a laser beam, such as an excimer laser beam, of appropriate diameter. The nozzle plate, complete with nozzles, is then bonded to the body of the apparatus with each nozzle aligned with a respective chamber formed in the body.

The use of plastics material for the nozzle plate tends to make the nozzle plate relatively weak, and thus prone to mechanical damage. Whilst stiffer materials, such as metallic or ceramics material, may be used for the nozzle plate, accurate nozzles are less readily formed in the nozzle plate.

It has been proposed in the prior art, e.g. from WO 02/098666, that nozzle plates may be formed from a metal plate containing an aperture into which a polymer material is injected. A nozzle is subsequently formed through the polymeric material.

In certain of its embodiments the present invention seeks to provide an improved method for manufacturing a component for use in a droplet deposition apparatus.

In an aspect of the present invention there is provided a method of forming a nozzle plate component for a droplet deposition apparatus, said method comprising

the steps: forming a body of a first material said body having a periphery, forming a plate of second material around said body such that the plate extends around at least a portion of said periphery of said body; and forming a nozzle extending through said body.

The plate is preferably formed by an electroforming technique.

The first material may be, for example, a positive or negative photoresist material. Especially preferred is a negative photoresist such as SU-8. The material may be masked and exposed to a form of radiation e.g. light to develop the un-masked portions.

The photoresist may be spun onto a substrate as a layer and subsequently processed to provide a plurality of distinct bodies. The substrate and where applied, a seed layer, may be used to form the plate material by electroforming or electroplating. The seed layer may be a sacrificial layer of copper or some other appropriate material. The nozzle plate may be formed from nickel or an electroformable alloy of nickel.

The substrate may also be used, as a support during subsequent manufacturing steps e.g. attaching the actuator unit to the nozzle plate, building electrical tracks on the nozzle plate etc. The polymeric bodies continue to provide structural support to the nozzle plate.

The bodies may be provided as an array and thus form the plate such that the material of the plate surrounds at least a portion of the periphery of the each of the bodies.

In a particularly preferred embodiment nozzles are formed through the body by an ablative technique. Other techniques such as punching or etching may provide a nozzle of appropriate quality.

The nozzle plate component may be attached to a droplet deposition apparatus prior to or post forming nozzles through the bodies.

The robustness of the nozzle plate may be further increased by providing a further material which extends over a surface of the plate and preferably also over a surface of the body. The location of the further material, which may be

electroformed, may be defined by a further, non-permanent, resist defining an aperture through which droplets are ejected from the nozzles.

In one embodiment an insulating layer is provided on a surface of the nozzle plate component. Beneficially this allows for the possibility of electrical tracks being provided on said insulating layer. The tracks may be used to connect electrodes on the droplet deposition apparatus with a remote driver circuit.

In a further aspect there is provided a method of forming a nozzle plate for droplet deposition apparatus, the nozzle plate defining a nozzle plate plane and comprising a plate having at least one nozzle plate layer and a plurality of nozzles, each nozzle extending through polymeric material located within an aperture within the nozzle plate, the method being characterised by the steps of defining a plurality of distinct bodies of polymeric material distributed over the nozzle plate plane and forming at least one metal nozzle plate layer by electroforming around said bodies of polymeric material.

Preferably, the nozzle plate comprises a first nozzle plate layer containing said apertures and the polymeric material located within said apertures through which the nozzles extend, and a second nozzle plate layer comprising a guard layer.

In yet a further aspect, the present invention consists in a method of forming a nozzle plate component for a droplet deposition apparatus, said method comprising the steps of: forming a layer of first photoresist material on a substrate; selectively exposing and removing photoresist material to define on the substrate an array of distinct bodies of said first material; forming a first plate of metal around said bodies, so as to form a metal nozzle plate having apertures, each aperture containing a body of said first material; and forming a nozzle extending through each body.

The present invention will be described, by way of example only, with reference to the following drawings in which:

Figure 1 shows a nozzle plate structure known in the prior art .

Figures 2a) to 2e) show a method of manufacturing a nozzle plate according to the present invention.

Figure 3a) to 3c) describe a technique of forming a guard on a nozzle plate.

Figure 4a) to 4c) show a method of forming a nozzle plate for attachment to an electrical circuit.

Figure 1 depicts a nozzle plate according to WO 02/098666. The nozzle plate 1 is formed of a metallic plate 2 with an etched aperture. A polymeric material 4 is inserted into the aperture and subsequently a nozzle bore 6 is formed either by punching or ablation.

Figure 2a) to e) describes a method of forming the nozzle plate component according to the present invention. A copper seed layer 8 is deposited onto a substrate 10. A layer 12 of photoresist is spun onto the seed layer.

A preferred photoresist material is SU-8, a negative, epoxy-type, near-UV photoresist based on EPON SU-8 epoxy resin (from Shell Chemical) originally developed by IBM and the subject of US Patent No. 4882245. SU-8 epoxy resin is a fully epoxidized bisphenol-A/formaldehyde novolac co-polymer having a characteristically inherent rigid molecular structure. Combined with the appropriate photo acid generator (PAG), it becomes a thick film negative resist. SU-8 photoresist is commercially available from MicroChem Inc. (previously Microlithography Chemical Corp.), 1254 Chestnut Street, Newton, MA USA. Further information is available at: http://www.microchem.com/products/su_eight.htm

The photoresist is masked, exposed and developed to leave a plurality of discrete bodies 4. The plate material 2 is subsequently electroplated or electroformed onto the copper seed layer thus forming a composite nozzle plate unit. The preferred plate material is nickel or an appropriate electroformable alloy of nickel.

The nozzle plate unit may be released from the substrate by etching the copper seed layer to form a nozzle plate component. Nozzles may then be formed through the in-situ photoresist material either before the nozzle plate is attached to an actuator unit (ex-situ) or after the nozzle plate is attached (in-situ).

It has been discovered that SU-8 photo resist can be ablated at a constant high fluence(8J/cm2) without damage to the nozzle plate. The benefit of ablating at

a high fluence is that the nozzles may be formed at up to three times the rate of conventional methods.

Overplating a portion of the resist provides a level of mechanical protection to the nozzles from paper impacts etc.

One of the additional benefits of the present technique is that the structural photo-imageable resists allow further structures to be built on the nozzle plate before ablating the nozzles and whilst it is still attached to the substrate.

In Figure 3, a guard plate is formed on the nozzle plate thereby providing an protective layer. Firstly a second layer of photoresist 12 is deposited onto the nozzle plate component and this is patterned, exposed and developed to leave portions which extend over the structural resist. This photoresist material will typically be different from the first photoresist material and a wide range of photoresist materials will be suitable.

A metal layer 14 is electroformed around the photoresist 12 and subsequently the photoresist is removed to leave apertures. Nozzles are then formed as described above.

In a modification, the nozzles are formed prior to removal of the second photoresist with the nozzles being ablated through the photo resist to protect what will become the front face of the nozzle plate.

It is also possible to form other features that may be located on either side of the nozzle plate. Figure 4 illustrates a technique of forming a nozzle plate having a conductive track attached thereto. The electroformed plate, whilst still attached to the substrate has spun thereon a further layer of an electrical insulation material 20 which will isolate the metal of the nozzle plate component from the metallic tracks formed in the track component 22. The track component may be a separately formed sheet or may simply comprise tracks formed onto the insulating sheet 20.

A wide variety of modifications can be made without departing from the scope of the invention. Thus, the described arrangements are only examples of arrangements of nozzle plate layers with at least one metal nozzle plate layer being formed by electroforming around said bodies of polymeric material. A guard layer

may be formed in this way on a nozzle plate layer formed - for example - by one of the techniques disclosed in WO 02/098666.

Whilst, the combination of a nickel nozzle plate electroformed around defined bodies of photo resist material is particularly preferred, the skilled man will recognise that there are a variety of techniques for forming a body of preferably plastics material, said body having a periphery, and forming a plate of preferably metal material around said body such that the plate extends around at least a portion of said periphery of said body. Similarly nozzles can be formed in a variety of ways other the preferred technique of laser ablation.

Each feature disclosed herein may be used either alone or in conjunction with one or more of other disclosed features.